Novel Composite Materials for SOFC Cathode Interconnect Contact

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Grant Number: DE-FG26-05NT42533
Performance Period: Oct. 2007 – June. 2008

OBJECTIVES

The overall goal of the research project is to develop a novel low-cost and damage-tolerant Ag-base alloy+perovskite composite material with low Ag evaporation/migration, suitable coefficient of thermal expansion, oxidation resistance, electrical conductivity, chemical stability and compatibility tailored compositionally and microstructurally for intermediate-temperature solid oxide fuel cell (SOFC) cathode-interconnect contact application. More specifically, the objectives of this research project include:

1) Elucidation of the mechanism of Ag evaporation at elevated temperatures;
2) Alloy design of new Ag alloys with significantly reduced Ag evaporation/migration;
3) Optimization of processing and microstructures of Ag alloy+perovskite composites;
4) Demonstration/assessment of performance of the new contact materials.

ACCOMPLISHMENTS ACHIEVED DURING THE CURRENT PEROFRMANCE PERIOD

The evaporation testing of a number of Ag-base alloys and Ag+perovskite composites has been completed using the standard exposure parameters. The effect of various alloying additions at a level of 1at.%, 5at.% and 15at.% on the Ag evaporation rate was determined and several elements such as Mn and Sn significantly modified the Ag evaporation behavior. A close look of the Ag-Mn and Ag-Sn alloys indicates that the additions of Mn and Sn led to the formation of a surface oxide scale during initial exposure, which consumed the alloying elements in the Ag alloy and at the same time caused weight gain for the samples; however, during additional exposure, the evaporation behavior of the alloys was essentially the same as pure Ag. Clearly, the porous oxide scale formed on these alloys was not effective in blocking Ag evaporation.

The Ag evaporation behavior of the Ag+peroviskite composites with different Ag-to-perovskite ratios was also evaluated. The powders with the desired Ag-to-perovskite ratios were mixed, pelletized, sintered at 850°C prior to testing. Two types of perovskite phases, LSCF ($La_{0.6}Sr_{0.4}Co_{0.8}Fe_{0.2}O_3$) and LSM ($La_{0.8}Sr_{0.2}MnO_3$), were included in the study. The Ag content in the composite varied from 0 to 100%. It was found that the composites showed a slightly reduced, yet comparable Ag evaporation rate to pure Ag. This can be attributed to the fact that these composites were quite porous and Ag could escape from the composite materials via the interconnected voids.

Thermal cycling of both Ag+LSCF and Ag+LSM composites was carried out using a specially-designed test rig, with ASR data being recorded at 5-minute intervals. The ASR exhibited relatively linear behavior for both composites with the number of thermal cycles, with the slopes of the trend lines increasing as the Ag content decreased. Even a small amount of Ag addition (e.g. 10% Ag) significantly reduced the cell ASR, indicating the effectiveness of Ag in relaxing thermal stress and minimizing thermal cycle-induced damage. The most interesting observation from the SEM cross-sectional view was the presence of a thick layer of Fe oxide (~60 μm) on the interconnect for the 100% LSM contact test cell, which was not detected for the other cells. This abnormal scale growth might be related to cracking near the contact/interconnect interface during thermal cycling, leading to the accelerated oxidation of the interconnect.

FUTURE WORK

The evaporation testing will be conducted for the Ag+perovskite composites with different microstructures as obtained by changing the processing/sintering conditions. Electrical characterization of the interconnect/contact/cathode test assembly will be conducted during isothermal holding as opposed to thermal cycling to determine the ASR degradation rate of the Ag+perovskite composite contact layers in absence of damage induced by thermal cycling. The effectiveness of the contact materials on blocking Cr migration from the interconnect alloy to cathode will also be demonstrated.

LIST OF PAPER PUBLISHED, CONFERENCE PRESENTATIONS, STUDENTS SUPPORTED UNDER THIS GRANT

Publications:

- "Thermal Evaporation of Pure Ag in SOFC-Relevant Environments", Z.G. Lu and J.H. Zhu, Electrochemical and Solid-State Letters, 10(10), B179-B182 (2007).
- "Electrical Contact and Contact Materials for Solid Oxide Fuel Cell Stacking ", J.H. Zhu et al., to be submitted to J. Electrochemical Society, 2008.

Conference Presentations:

- "Evaporation of Pure Ag under SOFC Operation Conditions", Z.G. Lu and J.H. Zhu, Presented at the Symposium Fuel Cells and Energy Storage Systems: Materials, Processing, Manufacturing and Power Management Technologies, MS&T 06, Cincinnati, Ohio, October 15-19, 2006.
- "Development and Characterization of Ag-LSCF Composite Contact Material for SOFC", Presented at the Symposium Fuel Cells and Energy Storage Systems: Materials, Processing, Manufacturing and Power Management Technologies, MS&T 06, Cincinnati, Ohio, October 15-19, 2006.

Student Supported Under this Grant:

- David Ballard, Jacky Shoulders, and Lucas Wilkinson, graduate students in Department of Mechanical Engineering, Tennessee Technological University